Software & Data Integrity Failures

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- Code and infrastructure not protected against integrity violations, e.g.
  - application relies upon plugins, libraries, or modules from untrusted sources, repositories, and content delivery networks (CDNs)
  - insecure CI/CD pipeline introduces the potential for unauthorized access, malicious code, or system compromise
  - auto-update functionality downloading and applying updates without sufficient integrity verification
- Objects or data encoded or serialized into a structure that an attacker can see and modify is vulnerable to insecure deserialization, e.g. insecure native serialization formats and libraries being used

Data Factors

A08:2021 – Software and Data Integrity Failures

CWEs Mapped	Max Incidence Rate	Avg Incidence Rate	Avg Weighted Exploit	Avg Weighted Impact	Max Coverage	Avg Coverage	Total Occurrences	Total CVEs
10	16.67%	2.05%	6.94	7.94	75.04%	45.35%	47,972	1,152

Prevention

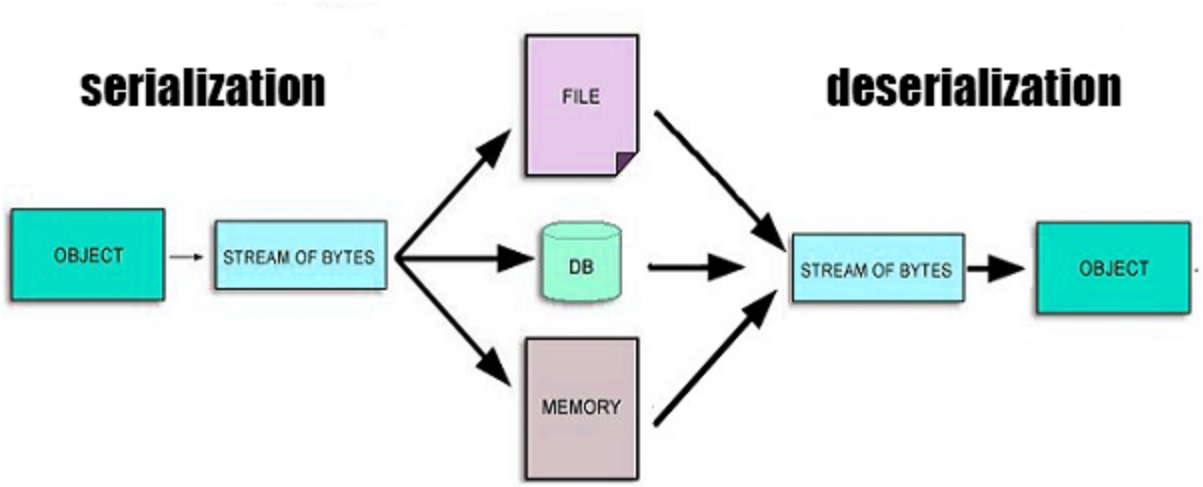
- **Using digital signatures** to verify the software or data is unaltered and from the expected source
- Ensuring libraries and dependencies (e.g. `npm` or Maven) **consume trusted repositories**
- Hosting an internal known-good and vetted repository as a proxy
- Using a software supply chain security tool (e.g. OWASP Dependency Check or OWASP CycloneDX) to verify that components do not contain known vulnerabilities

- Establishing a review process for code and configuration changes to minimize the chance that malicious code or configuration could be introduced into the software pipeline
- Establishing a CI/CD pipeline with proper segregation, configuration, and access control to ensure the integrity of the code flowing through the build and deploy processes

Deserialization

Serialization

> Object serialization transforms an object's data to a bytestream that represents the state of the data. The serialized form of the data contains enough information to recreate the object with its data in a similar state to what it was when saved. [^1]



Deserialization

```
InputStream is = request.getInputStream();
ObjectInputStream ois = new ObjectInputStream(is);
AcmeObject acme = (AcmeObject)ois.readObject();
```

- The casting operation to `AcmeObject` occurs **after** the deserialization process ends
- It is not useful in preventing any attacks that happen during deserialization from occurring

Insecure Deserialization

- Insecure deserialization often leads to **remote code execution** (RCE), one of the most serious attacks possible
- Other possible attacks include
  - replay attacks
  - injection attacks
  - privilege escalation
  - DoS

Exercise 8.2

1. What happens when the `root` object would be deserialized?

```
ArrayList<Object> root = new ArrayList<>(Integer.MAX_VALUE);
```

Exercise 8.3

1. What happens when the `root` object would be deserialized?

```
Set root = new HashSet();
Set s1 = root;
Set s2 = new HashSet();
for (int i = 0; i < 100; i++) {
  Set t1 = new HashSet();
  Set t2 = new HashSet();
  t1.add("foo");
  s1.add(t1);
  s1.add(t2);
  s2.add(t1);
  s2.add(t2);
  s1 = t1;
  s2 = t2;
}
```

Prevention

- **Avoid native deserialization formats** 💯
  - JSON/XML lessens (but not removes) the chance of custom deserialization logic being maliciously repurposed
- Use the Data Transfer Object (DTO) pattern
  - Exclusive purpose is data transfer between application layers

If serialization cannot be avoided

- Sign any serialized objects & only deserialize signed data
- Enforce strict type constraints during deserialization before object creation (Not sufficient on its own!)
- Isolate deserialization in low privilege environments
- Log deserialization exceptions and failures
- Restrict or monitor incoming and outgoing network connectivity from containers or servers that deserialize
- Monitor & alert if a user deserializes constantly

✓ SerialKiller (Java)

Replacing every `java.io.ObjectInputStream` instanciation

```
ObjectInputStream ois = new ObjectInputStream(is);
String msg = (String) ois.readObject();
```

with `SerialKiller` from a look-ahead Java deserialization library

```
ObjectInputStream ois = new SerialKiller(is, "/etc/serialkiller.conf");
String msg = (String) ois.readObject();
```

secures the application from untrusted input. Via `serialkiller.conf` classes can be block- or allowlisted.

❌ node-serialize (JavaScript)

The `node-serialize` module uses `eval()` internally for deserialization, allowing exploits like

```
var serialize = require('node-serialize');
var x = '{"rce":"_$$ND_FUNC$$_function (){console.log(\'exploited\')}()"}'
serialize.unserialize(x);
```

⚠️ *The affected version `0.0.4` of `node-serialize` is also the latest version of this module!*

Exercise 8.4 (🏠)

1. Report at least one of two typosquatting dependencies that the Juice Shop fell for (★★★★ - ★★★★★)
2. Report another vulnerability that could be exploited in a Software Supply Chain Attack (★★★★★)

Exercise 8.5 (🏠)

1. Find the „NextGen“ successor to the half-heartedly deprecated XML-based B2B API
    - This new API uses a popular standard for REST API specification & documentation
2. Exploit this API with at least one successful DoS-like Remote Code Exeution (⭐⭐⭐ - ⭐⭐⭐⭐⭐⭐)

ℹ️ *If the server would need >2sec to process your attack request, it is considered „DoS-like“ enough.*